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EFFECT OF TEMPERATURE ON GLOMERELLA

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WITH FOUR FIGURES IN THE TEXT

Among the factors which regulate the distribution and severity of plant diseases in tropical and sub-tropical climates is that of a continued high temperature. Very little is written concerning the effect of high temperature on the development of plant diseases and it is doubtful if this factor receives the consideration that it should. However it is interesting to note that recently Miss Westerdijk[1] has called attention to the fact that plant diseases are not abundant in the tropics. This is particularly interesting as it bears out many results obtained in Louisiana which are contrary to the common opinion that warm weather and a high humidity are the best conditions for disease development. In Louisiana, there is both the high temperature and high humidity and there has been a good opportunity to study the effect of these on the development of various diseases. The southern part of Louisiana has a sub-tropical climate with a short, comparatively cool winter, and a long summer with continued high temperature. While the heat of the summer is not excessive, there is a period from the last of May until the last part of September in which the minimum temperature is rarely under 70° F. and the daily maximum rarely under 90° F. This gives a considerable period in which vegetation is subjected to a continued high temperature.

There are, of course, many diseases which develop and spread during the hottest weather of the summer in Louisiana. These include the various wilt and root rot diseases, and many leaf troubles such as the angular leaf spot of cotton, the various Cercospora diseases, and so forth. Then there are diseases which are common in more northern climates during the summer season that develop satisfactorily in Louisiana only during the cool winter or spring months. These are represented by such

[1] Westerdijk, Johanna. Phytopathology in the tropics. Ann. Missouri Bot. Garden **2**: 307–313. 1915.

diseases as the onion mildew which attacks the plants during the winter and spring months and then lies dormant during the summer, and by the bean anthracnose which develops on the spring crop of beans and dies out entirely during the summer months. Finally, there is a third class of diseases, a group common in northern states, that does not occur in Louisiana or at least but sparingly. In this group may be placed such diseases as the sycamore anthracnose, caused by *Gnomonia veneta*, and most of the diseases caused by members of the Erysiphaceae. The sycamore anthracnose, although abundant in the northern states, apparently does not occur in Louisiana. The host is abundant and other than the high temperature of the summer, conditions would seem to be ideal for the development of the parasite. The whole group of the Erysiphaceae are very uncommon in Louisiana. Specimens of powdery mildews are only occasionally collected and then only in the winter and early spring.

PREVIOUS INVESTIGATIONS

In previous publications by the writer[2] on the bean anthracnose disease, the effect of a high temperature on the development of the causal fungus has been pointed out and discussed. Field studies carried through several years showed conclusively that this fungus would not develop during the hot summer months in Louisiana. The disease develops abundantly on the spring crop of beans, if diseased seed is used for planting; but if the seed is planted in August, as is necessary if a fall crop of beans is desired, the disease does not appear and the pods remain perfectly healthy. This fact is of considerable importance from an economic standpoint as a crop of clean beans can be raised in the fall which can be used for planting the main crop in the spring.

OBJECTS OF THE INVESTIGATION AND METHODS EMPLOYED

From the results obtained in the field work, it seemed desirable to continue the investigation and to test the bean anthracnose fungus carefully under laboratory conditions with all of the varying factors under control. The rate of growth at different temperatures and the optimum and maximum temperatures seemed to be important points in order to understand the life history of the fungus and the development of the disease. It also seemed desirable to test in the same way various other strains of the genus Glomerella for comparison. Many of the strains

[2] Edgerton, C. W. The bean anthracnose. Louisiana Agr. Exp. Sta. Bul. 119. 1910.

Edgerton, C. W. The bean blight and preservation and treatment of bean seed. Louisiana Agr. Exp. Sta. Bul. 139. 1913.

of Glomerella are very closely related and it seemed possible that the temperature factor might be helpful in separating the different ones. Data on the fungus causing the apple anthracnose or bitter rot disease also seemed to be of importance as previous investigations by different workers had shown that there are probably two distinct forms with different temperature requirements on the apple.

In order to procure the desired data, forty-nine cultures of Glomerella from twenty-two different host plants were obtained. The majority of the cultures came from Louisiana, but there were a number from other parts of the country and from the tropics. The host plants and the number of cultures from each host were as follows: apple (8), bean (10), lima bean (1), orange (3), banana (2), watermelon (2), American persimmon (2), Japanese persimmon (1), cotton (3), sugar cane (1), fig (3), blackberry (2), pecan (1), *Ficus elastica* (1), *Oxyanthus isthmia* (1), *Ipomoea purpurea* (2), *Solanum carolinense* (1), *Passiflora incarnata* (1), *Desmodium tortuosum* (1), *Melia azederach* (1), *Narcissus sp.* (1), *Sambucus canadensis* (1). These cultures represented practically all of the common types of Glomerella that are found in this country. A number of these were ascogenous cultures while the rest produced only the Gloeosporium or Colletotrichum stage. Both the plus and minus strains[3] of two forms were used, these being from blackberry and from *Ipomoea purpurea*.

These different cultures were grown at various temperatures ranging from 14°C. to 37.5°C. For the temperatures between 14° and 31°, a Hearson low temperature incubator was used, while an ordinary bacteriological incubator was used for the higher temperatures. The cultures were grown in petri dishes on agar made from bean pods. All the agar used was made at one time to eliminate all chance of variation in the medium. Three plates were made of each culture. A small bit of mycelium from the edge of a rapidly growing colony was transferred to the center of each plate. All of the plates of all of the cultures were placed in the incubator as soon as they were made and allowed to develop for five or six days. Every twenty-four hours, the diameter of each colony was measured. The daily growth of the colony was then obtained by averaging the increase in diameter for the last three or four days. The growth of the first twenty-four hours was never considered. Sets of plates were incubated at 14°, 16°, 19°, 21°, 23°, 25°, 27°, 29°, 31°, 33.3°, and 37.5°C. In any test where there was any question, either on account of contamination or for other reasons, duplicates were made as checks. Also sets were incubated at the same temperature at different times

[3] Edgerton, C. W. Plus and minus strains in the genus Glomerella. Amer. Jour. Botany **1**: 244–254. 1914.

in order to make certain that the cultures were not deteriorating or that the rate of growth was not changing. No culture that showed signs of "running out" or of deterioration was used in the tests.

The results of these tests will be shown by curves as space does not permit the tabulation of all of the figures that were obtained. The curves show the daily growth, or actual increase in the diameter of the colony in millimeters at any given temperature, and also the optimum and maximum temperatures for growth of each culture. The curves also aid in determining the similarity or dissimilarity of the different forms.

COMPARISON OF CURVES OF GROWTH

In figure 1 is shown the growth curves of thirty different cultures of Glomerella. While there were nineteen more cultures in the tests, these all came within the group designated in the figure as *b* and it did not seem necessary to add these to the already crowded figure. An examination of these curves will show two important things. There is a great difference among the forms in regard to temperature, a difference in the rate of growth and in the optimum and maximum temperatures. Also the curves of all of the forms studied fall readily into six well defined groups, marked *a*, *b*, *c*, *d*, *e*, *f* in the figure.

In group *a*, are shown the curves of growth of two different cultures of the fungus of banana anthracnose, *Gloeosporium musarum*. One of these had been growing on culture media in the laboratory for over a year before the experiments started, while the other one was isolated just as the work commenced. Cultures of the banana form grow much more rapidly than any of the others and the optimum temperature for growth is also higher. At the optimum temperature of 29° to 30°C., the colony increased in diameter nearly 22 mm. in 24 hours. There is practically no difference in the growth curves of the two cultures.

In group *b* fall the greatest number of the cultures from the various hosts studied. In this group are the cultures from *Oxyanthus isthmia*, *Ipomoea purpurea*, *Ficus elastica*, *Solanum carolinense*, *Passiflora incarnata*, *Desmodium tortuosum*, *Melia azederach*, *Narcissus sp.*, *Sambucus canadensis*, orange, cotton, sugar cane, fig, blackberry, Japanese persimmon, one of the cultures from the American persimmon, part of the apple cultures, and some saprophytic forms from bean. The optimum temperature for all of these was between 27° and 29°C. The maximum rate of growth was from 11 to 14 mm. per day. The maximum temperature was above 37.5°C. In this group are found the forms which commonly produce the perithecial or ascogenous stage. Many of the cultures that were used in this experiment were producing perithecia abundantly, including all three

of the apple cultures which fell in this group. The fungi in the group showed many differences in regard to such characters as the relative abundance of conidial masses, color of mycelium and culture medium, and so forth, yet the cultures of all showed a scanty development of aerial mycelium. In this group, apparently, would be found most of the

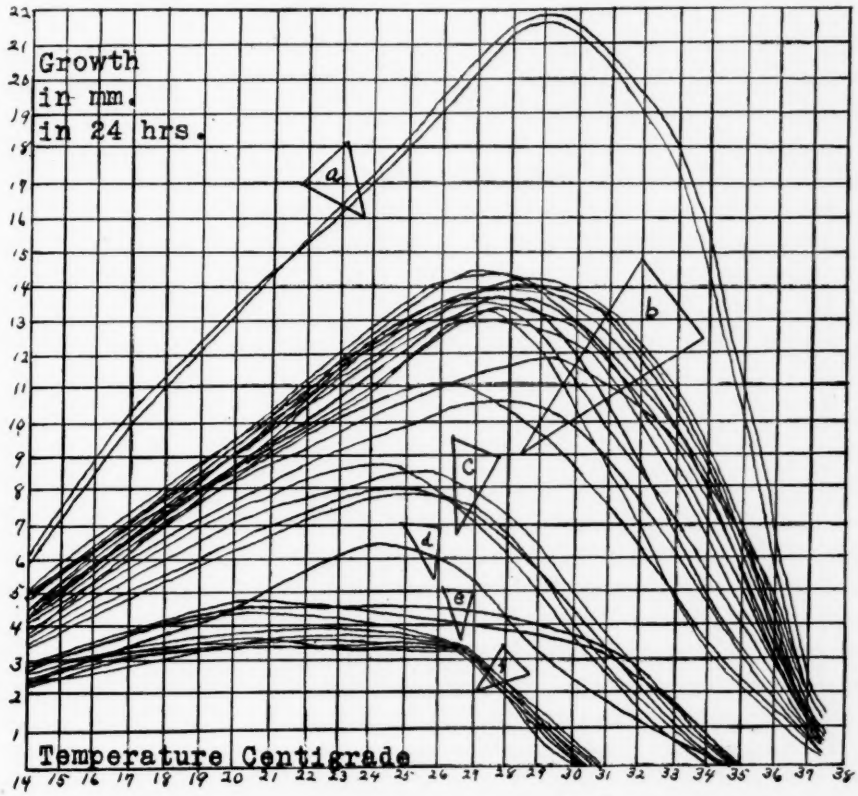

FIG. 1. Curves of growth of 30 different cultures of Glomerella at varying temperatures. (*a*) Gloeosporium musarum. (b) Glomerella cingulata, Glomerella gossypii, and related forms. (*c*) Gloeosporium fructigenum. (*d*) A slow-growing form from apple. (*e*) Colletotrichum lagenarium. (*f*) Colletotrichum lindemuthianum.

forms that are so common on dead and dying parts of various plants and also many of the true disease producing forms.

In group *c* are three cultures from the apple and one from the American persimmon. These were cultures of the fungus that is so common on apples and various other fruits and vegetables in the northern states. While this fungus occurs to some extent in the south, it is not so common

as in cooler climates. The optimum temperature for growth is about 25°C. and the maximum between 34° and 35°C. The maximum rate of growth at the optimum temperature on the medium used was from 8 to 9 mm. per day. Besides the reaction to temperature, cultures of this fungus, on the medium used, differ from those in group *b* by the comparatively dense development of pure white aerial mycelium. As far as the experience of the writer goes, cultures that would fall in this group do not produce perithecia. Many cultures of apparently the same fungus as was used in these tests, from many host plants and from many places, have been studied within the past several years but in no case have perithecia been observed.

In group *d* is found a single culture from apple. This had an optimum temperature for growth of 25°C. and a maximum of about 34°C. The increase in diameter at the optimum temperature was between 6 and 7 mm. per day. This was a very peculiar culture and from all appearances it was growing saprophytically on the apple and had no relation to the true apple anthracnose. The culture was very black in color, approaching the fungus of bean anthracnose in appearance. The spores developed very profusely and were identical in appearance with other spores of anthracnose fungi. As far as known, no other worker has had such an appearing culture from the apple. The culture was isolated from an apple sent from New York State.

In group *e* are two cultures of *Colletotrichum lagenarium*, cause of the anthracnose of watermelon. One of the cultures came from Delaware and the other from Louisiana. The optimum temperature for growth for this fungus was about 24°C. and the maximum temperature about 35°C. The increase in diameter of the colony at the optimum temperature was between 4 and 5 mm. per day. Cultures of the watermelon anthracnose fungus are characterised by the lack of a dark color and by the slimy development of spores. The spores developed so abundantly on the bean agar that a slimy pink covering was formed on the surface. Perithecia of this fungus have never been found.

In group *f* are cultures of the bean anthracnose fungus, *Colletotrichum lindemuthianum*. Eight different cultures were used in order to test any possible individual variation. These cultures came from different varieties of beans and from different parts of the country. The optimum temperature of growth for this fungus is somewhere around 22° to 23°C. though there is but very little difference in growth at temperatures between 19° and 26°C. The maximum temperature is between 30° and 31°C. The rate of growth at the optimum temperature was between 3 and 4 mm. per day. Cultures of the bean anthracnose fungus are characterised by their slow growth and by their very black color.

The relation of growth to temperature as shown by these curves throws considerable light on the distribution and destructiveness of some of the members of the genus Glomerella in different parts of the country. The fungi represented in groups *a* and *b* are very common in the southern states. They grow well at ordinary temperatures and will grow under a continued high temperature. The fungi in group *c* occur in the south

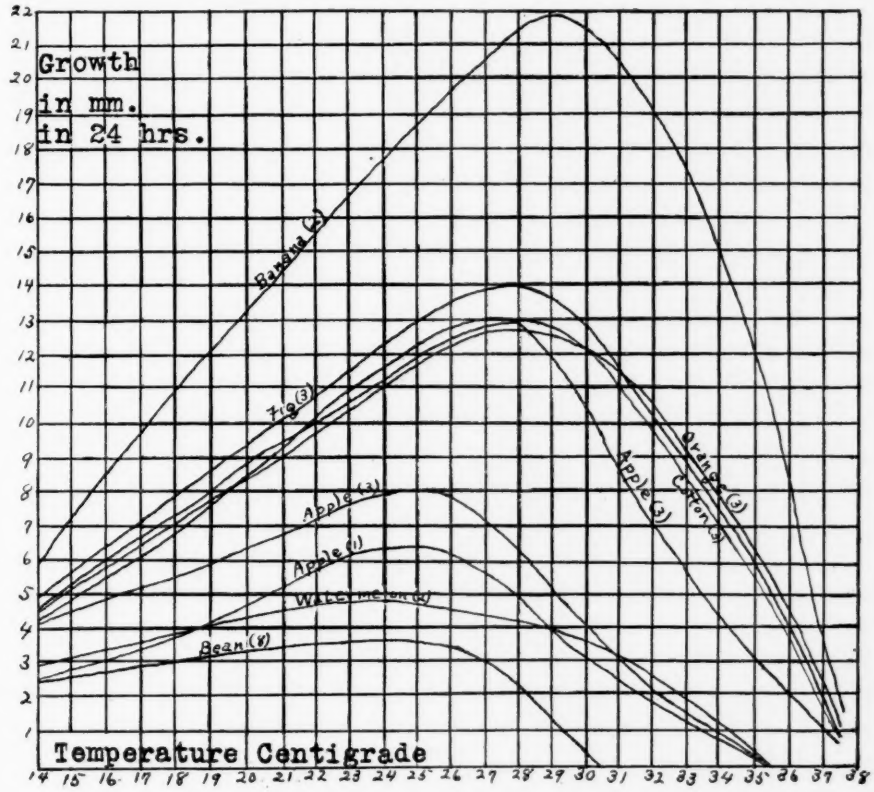

FIG. 2. Curves of growth of Glomerella cultures from several hosts. The figures in parentheses show the number of cultures that were averaged to form the curves.

but are more common and destructive in the north. The fungi in groups *e* and *f* do not thrive in the summer temperatures of the south. The watermelon anthracnose is not abundant in the south and there is practically no damage. In fact, only one specimen of this disease has been received at the Plant Pathology Laboratory in Louisiana in seven years. The bean anthracnose fungus will develop abundantly in the south in the spring during the cooler weather but is entirely killed out during the

summer months. It is interesting to note that it is even very difficult to keep a culture of *Colletotrichum lindemuthianum* alive in the laboratory during the summer season in Louisiana unless an ice box is available.

In order to show more clearly the relation of the several Glomerella forms to temperature, the curves of growth of several forms from different hosts are shown in figure 2. Each curve is made by averaging all the results obtained from like cultures from a single host; for instance, the curve representing the bean anthracnose has been made by averaging the curves of eight different cultures. The figures in parentheses after the host plant names, indicate the number of cultures used to make each curve. These show clearly the difference of the different forms in their reaction to the temperature factor. The curves also show why the bean anthracnose fungus will not live through the summer in the south and why the watermelon fungus and one of the forms from the apple are not common in that section of the country.

Comparison of cultures from the same host

Among the points of interest which were brought out by these experiments is the fact that cultures from the same host, with a few exceptions, show a remarkable similarity in regard to their reaction to temperature. Glomerella cultures are often extremely variable and it would not have been surprising if there had been a considerable variation in regard to the reaction to temperature. In figure 1, the similarity of the curves of the different cultures of *Gloeosporium musarum*, *Colletotrichum lagenarium*, *Colletotrichum lindemuthianum* and the slow growing form from the apple are readily seen. The cultures of the fungi from cotton, orange and fig also show as striking a similarity.

Comparison of cultures from the bean

Cultures from the bean gave some interesting results and formed one of the exceptions mentioned in the preceding paragraph. Ten cultures from this host were used in the experiments and the growth curves are shown in figure 3. In the figure are seen the eight similar curves of *Colletotrichum lindemuthianum* near the base line, the same as are shown in figure 1. Also the curves of two cultures are illustrated which show more rapid growth and higher optima and maxima temperatures. These two curves fall in group *b* described above. While these two cultures came from beans, it is certain that they do not belong to the species, *Colletotrichum lindemuthianum*. They have entirely different cultural characters and furthermore do not cause an infection on growing beans.

In the southern states almost any species of plant, after the tissue becomes old and has lessened vitality, will become infected with some of the forms of group *b*. Beans are no exception to this rule. These two organisms were evidently growing saprophytically on old bean tissue.

Of further interest is the fact that one of these rapidly-growing cultures from the bean is an ascogenous strain. It is doubtful if the perithecial stage of *Colletotrichum lindemuthianum*, the fungus causing bean anthracnose, has ever been seen. While hundreds of different cultures of this fungus have been made during the past few years, the writer has never seen any signs of perithecia in any of them. The asco-stage has been

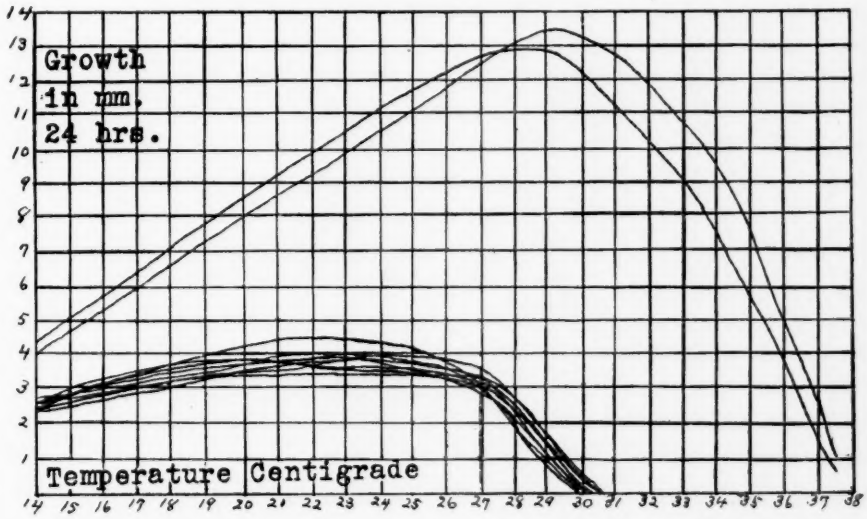

FIG. 3. Curves of growth of ten cultures of Glomerella isolated from bean. The curves near the base line represent the true bean anthracnose fungus, Colletotrichum lindemuthianum; the other two curves represent forms close to, if not identical with, Glomerella cingulata. The latter cultures were evidently accidental on the bean.

reported by Shear and Wood,[4] but after a careful consideration of the data given, it seems very doubtful if they were working with a culture of the true bean anthracnose fungus. They obtained their culture from an old bean pod, and as has been shown above, other ascogenous anthracnose fungi may occur on such material. Furthermore, they obtained a culture which produced perithecia alone and did not produce conidia.

[4] Shear, C. L. and Wood, Anna K. Ascogenous forms of Gloesporium and Colletotrichum. Bot. Gaz. **43**: 259–266. 1907.

Shear, C. L. and Wood, Anna K. Studies of fungous parasites belonging to the genus Glomerella. United States Bur. Pl. Ind. Bul. 252. 1913.

Frequently in Louisiana during the past few years, such non-conidial producing organisms have been isolated from old parts of a number of different plants. Two or three of the cultures described in group *b* in this article produce perithecia only. As Shear and Wood performed no inoculation experiments with their ascogenous culture to prove pathogenicity, it seems more reasonable to suppose that they had a culture of Glomerella that was accidental on the bean and was not the true bean anthracnose fungus itself. If this is the case, perithecia of *Colletotrichum lindemuthianum* have as yet never been seen; and until some one proves definitely that they do occur, it seems better to consider the bean anthracnose fungus as a non-ascogenous form.

Comparison of cultures from the apple

In a previous article,[5] attention was called to the fact that there seemed to be two different strains of the apple anthracnose, a rapid-growing southern form and a slow-growing northern form. This contention has not received serious consideration by many other workers as it is somewhat contrary to general opinion that not more than one strain should be found on a single host. In fact only two articles have been seen in which the existence of the two forms has been recognized. Lewis[6] has called attention to the fact that cultures isolated in Maine are not as virulent as the southern form. Schneider-Orelli[7] has investigated the apple anthracnose problem in Europe and has obtained some very interesting data. He obtained cultures from the United States and compared them with the European form. He found that the American form grew faster at the higher temperatures and also that the optimum and maximum temperatures were higher. The results which he obtained with the American form agree very closely with those of the rapid-growing form described in this article and it is evident that he had cultures of this fungus. From the data which he gives, it also seems very probable that the European form is identical with the American slow-growing form.

From the work of others and also from recent investigations, there seems to be no doubt that there are two distinct strains—probably species—occurring on apple in this country. The differentiating characters of the two forms are important and will be briefly described.

[5] Edgerton, C. W. The physiology and development of some anthracnoses. Bot. Gaz. **45**: 393, 402–403. 1908.

[6] Lewis, Charles E. Apple diseases caused by Coryneum foliicolum Fckl. and Phoma mali Schulz et Sacc. Maine Agr. Exp. Sta. Bul. 170: 189. 1909.

[7] Schneider-Orelli, O. Zur Kenntnis des mitteleuropaischen und des nordamerikanischen Gloeosporium fructigenum. Centralbl. Bakt. Paras. und Infektionskr. Abt. 2, **32**: 459–467. 1912.

One form grows rapidly, has higher maximum and optimum temperatures, produces but scanty aerial mycelium in culture, produces cankers on apple limbs besides rotting the fruit, occurs principally in the southern warmer parts of the apple belt, and very commonly produces perithecia on the host and in culture. It is probable that this fungus is identical with forms found on a number of hosts. If it is identical with the one found on Ligustrum, as seems probable, it should be called *Glomerella cingulata*.

The other form grows slowly, has lower optimum and maximum temperatures, usually produces a greater abundance of white aerial mycelium

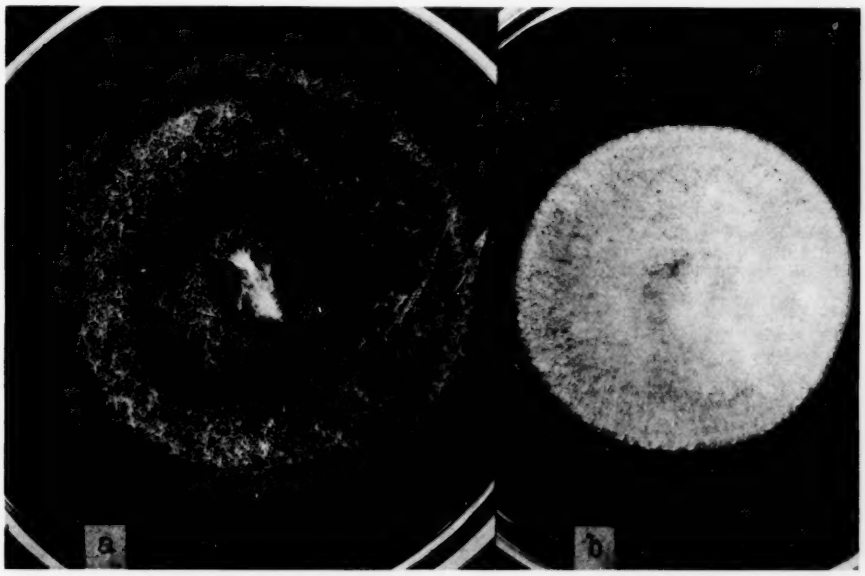

FIG. 4. Cultures of the two strains from apple, after six days of growth in bean agar at 27°C. (*a*) The rapid growing ascogenous form, Glomerella cingulata. (*b*) The slow-growing non-ascogenous culture, Gloeosporium fructigenum.

on most culture media, apparently does not produce cankers on apple limbs though it rots the fruit, occurs principally in the northern cooler sections, and apparently does not produce perithecia. From the standpoint of priority, it would be useless to try to find the proper name for this fungus as it occurs on a wide number of hosts and one cannot be sure which of the early descriptions refers to it. However, it is more than probable that Berkeley had this strain when he first described the apple rot, and for a lack of a better one, it seems well to use the name given by him, *Gloeosporium fructigenum*.

Comparison of cultures of other forms

The anthracnose fungi from watermelon and banana seem to be well marked species. Many different characters separate these from other forms and from each other. These are admitted to be distinct species by most workers in this group.

The fungi which have been described under group *b* represent the difficult ones from the standpoint of classification. These show a great many differences yet there are so many intergrading forms that it is impossible to separate them satisfactorily. Most of the forms without doubt should be referred to *Glomerella cingulata* but evidently not all of them. The form from cotton, *Glomerella gossypii*, seems to be fairly distinct from the others both from a morphological and a physiological standpoint and evidently should be considered a good species. Another form which has been previously mentioned, the one that produces ascospores and no conidia may also represent a distinct type, though the data are not as yet sufficient to show whether this is a constant character or whether it is a variation that may occur in many forms. There may also be a few other types which should be considered distinct but the evidence is not as yet clear.

CONCLUSIONS

Briefly the conclusions which have been reached in this paper may be stated as follows:

1. Regarding the reaction to temperature, the forty-nine cultures from twenty-two different host plants that were studied readily fall into six different groups as follows: (*a*) The form from banana, *Gloeosporium musarum*, a rapid-growing fungus, optimum temperature 29° to 30°C., and maximum temperature above 37.5°C.; (*b*) Forms from various hosts represented by *Glomerella cingulata* and *Glomerella gossypii*, forms with slower growth than the banana anthracnose fungus optimum temperature 27° to 29°C., and maximum temperature above 37.5°C.; (*c*) The form from apple and other hosts common in cooler climates and perhaps best known by the name of *Gloeosporium fructigenum*, a form with slower growth than the preceding, optimum temperature 24° to 25°C., maximum temperature 34° to 35°C.; (*d*) A form from apple not related to the forms above, characterised by its slower growth, optimum temperature 24° to 25°C., and maximum temperature 34° to 35°C.; (*e*) The form from watermelon, *Colletotrichum lagenarium*, a form with slower growth than the preceding, optimum temperature 24°C., and maximum temperature 34° to 35°C.; (*f*) The form from bean, *Colletotrichum lindemuthianum*, the

form with the slowest growth of any, optimum temperature 21° to 23°C., and maximum temperature 30° to 31°C.

2. The ascogenous forms of Glomerella seem to be confined to the groups having the most rapid growth, most of them falling in group *b*.

3. There are apparently two distinct anthracnose fungi found on apple in the United States. These are readily separated by the temperature reaction though there are other differences.

4. The bean anthracnose fungus, *Colletotrichum lindemuthianum*, will not tolerate a high temperature. This fact is utilized in the control of the disease in the warm regions of the country. Seed can be raised in the fall absolutely free of the disease and this can be used for spring planting.

5. A large number of forms from various hosts falling in group *b* cannot be separated by the temperature factor and it is probable that many should not be considered as distinct.

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RING-SPOT OF CAULIFLOWER

A. Vincent Osmun and P. J. Anderson

With Four Figures in the Text

Cauliflower in large quantities is shipped into eastern markets from California. Practically all the cauliflower from this source on the Boston market the latter part of March and early April was badly affected with a disease known in Europe as leaf spot and in Australia as ring-spot. No previous record of its occurrence in America has come to the notice of the writers. Since it has already caused considerable loss and bids fair to become an important disease here, as has been the case in other countries where it has been introduced, it has been made a subject of investigation by the writers. The work is still in progress, but this opportunity is taken to call the disease to the attention of pathologists.

Economic importance. Cabbage and cauliflower and some other Cruciferae are affected. In Europe the disease has attracted attention solely as a disease of cabbage. Cooke (1906) does not consider it a serious disease in England. In regard to its importance in Victoria, McAlpine (1901) writes: "Since it only occurs on the older leaves, and especially those which are already fading and withering, it is not regarded as of serious import. Still the outer and older leaves prematurely decay, and therefore the plant is bound to suffer from defective nutrition." Kirk (1906) takes a more alarming view of its inroads in New Zealand: "This troublesome parasite is undoubtedly greatly on the increase, and its attacks are becoming more virulent each year . . . . . , it is rapidly becoming the most serious pest that cabbage and cauliflower growers have to contend with." If this disease has but recently been introduced into America it is not possible to predict the course it will run here. We are all too familiar with diseases which are not particularly destructive in their native home but which cause great losses when brought to our shores.

Even if the damage to the crop while it is growing in the field is but slight,[1] a period of from twelve days to three weeks must elapse between the cutting of the cauliflower in California and the time it is placed on the market in Boston. Information obtained from Boston wholesale

[1] Prof. R. E. Smith, of the California Agricultural Experiment Station, informs the writers that this disease has not been observed in California.

dealers is to the effect that the consignors claim the cauliflower goes into the cars in a healthy, green condition. But although the cars are kept iced, conditions very favorable to the development of the disease evidently prevail during transit. In one car examined in the Boston freight yards the writers found three men employed solely to remove the diseased and yellow leaves from the outside of the heads in order to make them presentable on the market. One wholesale dealer estimates his loss from this trouble at from $300 to $400 per car. The problem in this country may be one of shipping and marketing rather than of growing the crop.

Symptoms. On the market only the leaves were found to be affected, but in Europe the pods of the cabbage are also said to become diseased. The outer leaves are much more seriously attacked than those near the center of the head. In light cases only a few spots occur on a leaf, and the leaves show no tendency to turn yellow. Other leaves have hundreds of spots on them, often so close that they coalesce (fig. 1). In the latter case the leaves turn yellow. Most of the spots are on the laminae, but the large midribs also may be affected. The spots are definite in outline, circular, average about 4 to 5 mm. in diameter (range from 1 mm. to over 1 cm.). They are visible on both surfaces of the leaf, have light brown or grayish dry centers, surrounded by olive-green or blue-green borders which shade off into the natural color of the leaf, but when the leaves have become yellow the lesions retain the green color and are very conspicuous against the yellow background. The green borders are often raised and may show a tendency to concentric circles. Very minute black dots, barely visible to the naked eye, cover the outer edges of the spots on both surfaces of the leaves. They are very densely crowded together in the outer parts of the lesion, but are either absent or more scattered in the central gray portion. After the leaves have stood for a while the dots also appear on the yellow tissue surrounding the spots. On the leaves collected here the minute points do not appear to be arranged in concentric circles, as has been reported in Europe by Grove (1914).

Causal organism. The disease and the fungus causing it have been known for nearly a century. Chevallier (1826) first described the fungus, giving it the name *Asteroma Brassicae*. From his description it is impossible to tell whether he observed the pycnidial or the perithecial stage. All subsequent students of the fungus apparently believe that he had only the former. Duby (1830) described the same fungus four years later as *Sphaeria brassicaecola*. Perkeley and Broome (1852) listed it as *Sphaeria Brassicae* and published a figure of the asci and ascospores. Evidently the latter were immature since they show no septa. Eight

years later Berkeley (1860) lists the fungus as *Sphaeria brassicaecola*. De Cesati and de Notaris (1863) changed the generic name and called it *Sphaerella brassicaecola*, giving also as a synonym *Dothidea Brassicae* Desmaz. (Ann. Sc. Nat. 1842, xvii). Saccardo (1882) gives as the correct name *Sphaerella brassicicola* (Duby) Ces. et de Not. He does not

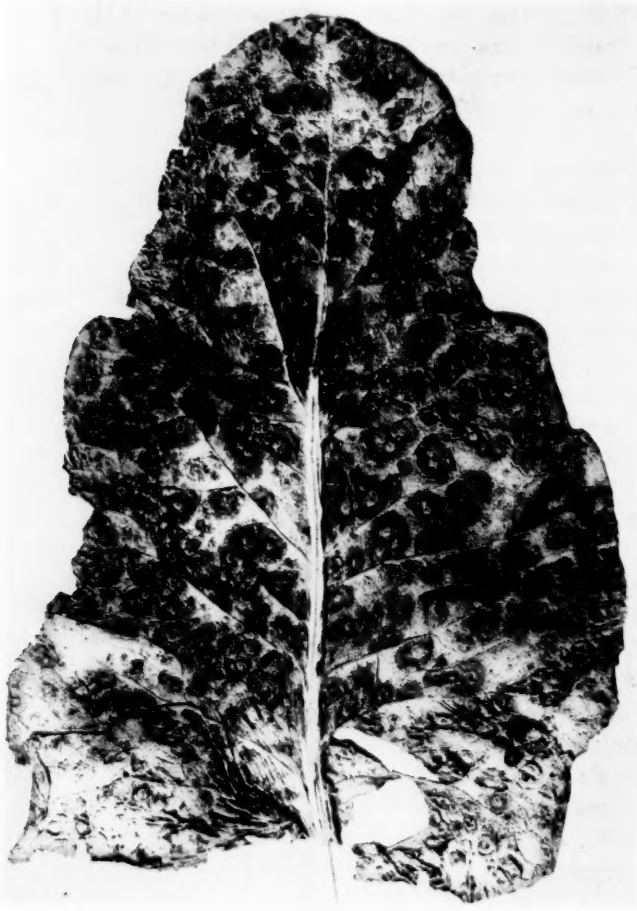

FIG. 1. Cauliflower leaf badly affected with ring spot. One-fourth natural size.

explain why he changed the spelling of the specific name. Duby and Cesati and de Notaris give *brassicaecola*. Lindau (1897) calls attention to the fact that the generic name Sphaerella must be discarded because it was previously applied to a genus of the Volvocaceae. He recommends the generic name, *Mycosphaerella*, which had previously been pro-

posed by Johanson. He gives as the correct name of the fungus *Mycosphaerella brassicicola* (Duby) Lindau.

The pycnidial form is a typical Phyllosticta, and McAlpine (1901) proposes the new combination *Phyllosticta brassicicola* McAlpine. Cooke (1906) gives *Phyllosticta Brassicae* (Curr.).[2] But Grove (1914) objects to the above name: "As there is already a *Phyllosticta Brassicae* Westd. having spores of a very different character and a different arrangement of the pycnidia, the present imperfect form will be named *P. brassicicola.*" He follows this with a comprehensive description of the new species. He does not state his reasons for disregarding the same combination proposed by McAlpine thirteen years previously.

That the pycnidial and perithecial forms are stages of one and the same fungus has been assumed by all; but actual proof of this fact, beyond that afforded by association, is wanting; nor has the pathogenicity of the

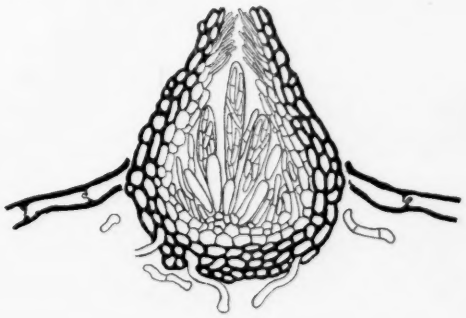

FIG. 2. Longisection of pycnidium of Mycosphaerella brassicicola. × 330.

organism been proved so far as the literature shows. When this disease was first brought to the attention of the writers, the possibility of the causal fungus being the same as that which produces "blackleg" was considered. The pycnospores of the two are identical in size and shape. Specimens of the latter were kindly furnished for comparison by Prof. T. F. Manns, of Delaware, and Dr. L. R. Jones, of Wisconsin. But the two diseases have an entirely different appearance on the plants, and the pycnidia of Mycosphaerella are much smaller and of a different shape. The diseases are evidently distinct.

The mycelium grows between and through the cells of the host. It is stout, rather closely septate, much branched, particularly characterized by the presence of numerous large oil drops. It is at first hyaline, but becomes darker with age.

[2] Currey's description of the fungus has not been seen by the writers.

The pycnidia are produced just beneath the epidermis on either surface of the leaf. The epidermis is ruptured at maturity, but the pycnidia do not project noticeably. They develop symphyogenetically and singly without stromata. In young stages they appear as balls of undifferentiated hyphae. Later, conidiophores of much smaller diameter than the hyphae branch off and fill the center of the mass. Even in mature pycnidia, branches of the large hyphae which made up the original hyphal ball may be seen in the central cavity (fig. 2). The pycnidium is small, generally globose, and dark colored externally on account of the thin outer shell of thick-walled cells. The pycnospores are formed in enormous numbers and ooze out through the ostiole in a pink, gelatinous thread. They are cylindrical, bacilloid, straight or slightly curved, obtuse at the ends, 1.5 to 2.5 by 2.5 to 4.5 μ.

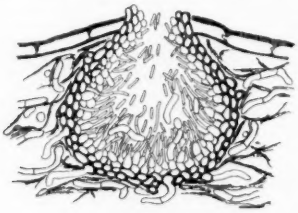

FIG. 3.

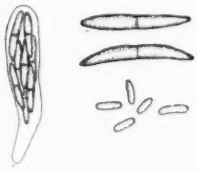

FIG. 4.

FIG. 3. Longisection of perithecium of Mycosphaerella brassicicola. × 330.

FIG. 4. Ascus, ascospores and pycnospores of Mycosphaerella brassicicola. The two ascospores and the pycnospores to the right are drawn to the same scale to show comparative size.

In Europe the pycnidial stage is said to be abundant on the green leaves, while the perithecial stage occurs only on the old dying leaves. The perithecial stage is said to be rare there (Grove, 1914), while in Australia it is said to be the commoner of the two. On the material examined here the perithecia are more abundant.

The perithecia also start their development just beneath the epidermis. In the young stage the perithecium is a globose mass of cells which increases rapidly in size and soon breaks through the epidermis. The center becomes filled with a tangle of hyphae composed of short, plump cells which later take on the character of paraphyses. A group of cells on the upper surface grows out to form the neck and the perithecium becomes pyriform. The asci develop in a tuft from the center of the lower part of the core. They do not develop simultaneously, but a few at a time, so that they may be found in various stages of development in the same perithecium. They elongate on maturity (fig. 3). Each ascus contains eight bilocular oblong or somewhat fusiform, hyaline ascopores

(fig. 4) 24.5 by 4.25 μ. The spores are straight or may be slightly curved (fig. 4). The mature perithecium measures about 90 μ broad by 115 μ high, projects from the surface, has a short, conical neck, is dark colored and has a much heavier wall than the pycnidium. At maturity the paraphyses have disappeared and periphyses line the inside of the neck. The perithecia are scattered thickly over the surface of the leaf and several of them may coalesce. No stroma is present.

Control. No control experiments have ever been reported. Kirk (1906) recommends spraying with bordeaux 4–4–50; McAlpine (1901) recommends various sanitary measures, but both admit that they have not tried either. In this country control measures may have to be effected through changes in shipping conditions. The present investigations have not progressed far enough to warrant recommendations.

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SIMPLE TECHNIQUE FOR ISOLATING SINGLE-SPORE STRAINS OF CERTAIN TYPES OF FUNGI

G. W. KEITT

WITH ONE FIGURE IN THE TEXT

As cultural studies of fungi have become more critical and methods more exact, standard technique has made very general and increasing demands for the isolation of single-spore strains of these organisms. Especially is this necessary in the comparative study of a number of closely related strains or species. In work of this type, the writer was confronted three years ago with the problem of making large numbers of single-spore isolations in limited time. This necessity led to the development of technique by which it was possible under favorable conditions to isolate easily as many as a dozen individual spores within an hour. This method is presented in the hope that it may be useful to others who are engaged in similar work and may thus save some duplication of the time and effort necessary for developing such technique individually. Though details are given it is clearly realized that many variations and modifications may be desirable to meet individual needs and preferences.

The process is merely a convenient and reliable method for executing the old idea of removing from agar plates to suitable substrata blocks of media bearing individual spores, and clearly establishing by subsequent observations that the isolations are free from contamination or admixture.

Media. For work of this type three primary requisites of the medium used are (a) clearness, (b) a suitable consistency, and (c) adaptation to the growth of the fungus to be isolated. While a large variety of substrata may be used with good results, a simple preparation of agar in water, to which a clear nutrient solution may be added, if desirable, at the time of plating, has proved very generally adaptable and satisfactory. The following method of preparation, which is, of course, subject to many minor variations, gives a very clear medium of a suitable consistency:

Dissolve 25 grams of agar (shreds preferred) in one liter of distilled water. Steam for two or three hours, or autoclave at ten pounds pressure for forty-five minutes. Cool to 50°C., add the white of one egg stirred in 100 cc. of distilled water, and mix thoroughly. Steam until a

firm, heavy coagulum is formed. Strain through cheesecloth to remove the bulk of the coagulum, and then through a cotton filter, in an ordinary funnel. The filtrate should be reasonably clear, and should give very good results without further treatment. If a force filter is available, however, the medium may be further clarified by running it through a Büchner funnel in which is placed a mat of macerated filter paper 3 to 5 mm. in thickness. Immediately before use, this apparatus should, of course, be thoroughly washed with hot water to remove all loose particles of filter paper, and to prevent cooling the agar and clogging the filter. Tube and sterilize. Unnecessary severity of sterilization should be avoided.

As a nutrient solution to be added to the agar at the time of plating, a well filtered prune decoction—10 to 50 grams of pitted prune per liter—

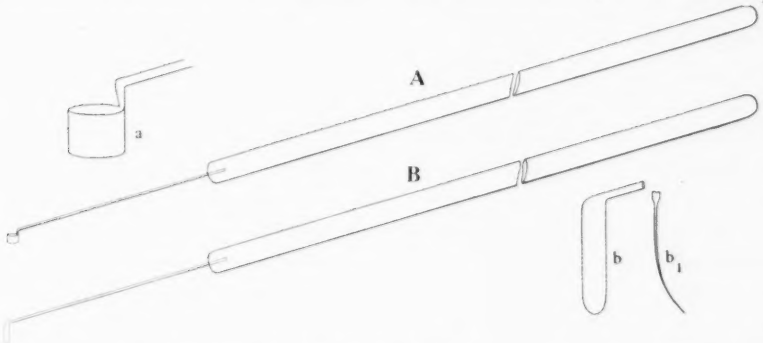

FIG. I. Devices for the isolation of individual spores from agar plates: *A*, instrument for cutting cylinder of the medium, × ½; *B*, instrument for transferring cylinder, × ½; *a*, part of *A* enlarged; *b*, part of *B* enlarged; b_1, end view of *b*.

has been found generally satisfactory. A great variety of solutions may be used, however, the chief requisites being clearness and adaptation to the growth of the fungus to be isolated.

Special instruments. The only specially prepared apparatus consists of two platinum or platinum-iridium wires worked into the shapes illustrated in figure 1. Their diameter and composition are determined with reference (a) to securing satisfactory rigidity and (b) to providing for as rapid cooling as possible after flaming. The writer has found 22 to 23 gauge wire satisfactory. Platinum-iridium gives better rigidity to the instruments than does platinum, but is harder to work. The hollow cylinder of instrument *A* is made at such an angle that its lower edge will be parallel to the bottom of the plate when the rod is held in the natural position for use, with the hand resting upon the table. A convenient diameter for the cylinder is 2 mm. It is well, however, to have

several instruments of different sizes. The angle of nearly 90 degrees and the slight lateral curve of the chisel of instrument *B* are found very convenient in picking up the agar discs. The hollow cylinder of *A* and the chisel of *B* should be thin, to facilitate the manipulations and to provide for rapid cooling. With a little practice a crude but efficient set of these instruments may be hammered out in a short time.[1]

Method. This work demands only those precautions against contamination which, according to standard technique, should attend the ordinary transfer of pure cultures. When such measures are properly observed, the danger of contamination is practically eliminated.

Pour a dilution series of plates of such nature that one will contain approximately one hundred to three hundred uniformly distributed viable spores, using media of the type above described. For most satisfactory work the depth of the medium in the plate should usually be about 1 mm.

If the spores are too small to be observed easily under the low power of the microscope, incubate the plates until the germ tubes become readily visible, but not long enough for the spores to lose their identity. Working thus with spores in the early stages of germination has the further advantage of providing against the isolation of those which are nonviable.

Study the inverted plates under the low power until the one with the most convenient dilution is determined, and a suitably situated spore is found. Mark the location of the spore carefully by means of an ink dot or a ring on the glass of the petri dish. A mechanical marker attached to the microscope may be used for this purpose, but a skilfully manipulated fountain pen is quite as satisfactory. Make an incision about the spore by means of instrument *A*, inserting it into the petri dish as one would an ordinary needle, and taking the usual precautions to prevent contamination. Invert the plate, and examine under the low power to ascertain whether the spore is uninjured and properly isolated. With instrument *B*, transfer the cylinder of agar bearing the spore to a fresh sterile plate of clear agar (the same medium used for plating is usually satisfactory), and deposit it in a depression previously prepared either by removing a cylinder with the same instruments and precautions used in the above process, or by gouging aside with instrument *B* enough of the medium to allow the transferred cylinder to rest upon the bottom of the petri dish. Note the position of the spore, and ascertain by low power examination whether it is properly isolated and uninjured. If it is necessary for satisfactory observations to use the higher power of the microscope, the transfer may, of course, be made to a van Tieghem cell, instead of a plate.

[1] Specifications for these devices have been given to the Bausch and Lomb Optical Company, from whom the instruments may be procured at a reasonable price.

Observe the development of the spore at intervals sufficiently frequent and numerous to establish beyond doubt that the development is from a single spore and uncontaminated.

Applicability. As used by the writer and a number of others in the laboratory of plant pathology of the University of Wisconsin, this method has proved easily workable, and well adapted to all the organisms tried. It appears to be generally applicable to most fungi which sporulate satisfactorily and germinate and grow on or in agar substrata. It has proved especially useful, further, for the isolation from field material of slow-growing fungi, which, with the ordinary poured plate method, are likely to be overrun by rapidly growing fungi or bacteria.

UNIVERSITY OF WISCONSIN

THE NEED OF A PURE CULTURE SUPPLY LABORATORY FOR PHYTOPATHOLOGY IN AMERICA[1]

C. L. Shear

The rapid development of phytopathology, the great increase in the number of workers in the field in recent years, and the adoption of more exact and improved methods, are bringing out and emphasizing the desirability of certain aids and improvements in our facilities for investigation. The particular matter to which I wish to call attention at this time is that of providing more adequate means for the collection, cultivation, distribution, and permanent preservation of pathogenic organisms and their relatives.

The relative importance of artificial cultures of pathogenic organisms, and fungi in general, has increased very rapidly in recent years and will undoubtedly continue to increase in the future. Recent investigations also indicate that more and more dependence must be placed upon the cultural characters and behavior of organisms in determining their identity and pathological relations. Formerly, reliance was placed chiefly or entirely on morphological characters in identifying fungi. As our knowledge derived from cultural studies and inoculation experiments increases we find that organisms may possess distinctive physiological characteristics not always accompanied by distinguishable morphological differences under natural conditions. Such organisms can, however, frequently be distinguished by cultural characters under artificial conditions or by inoculation experiments.

The unsatisfactory character of even the best descriptions as a means of positive identification of microscopic organisms has undoubtedly been at one time or another realized by most pathologists. This is particularly true in case of cultures even with the most exact and complete descriptions. The positive identification of an organism in culture is in many cases impossible without an authentic culture for comparison, and is in all cases greatly facilitated by such a culture. It would seem hardly necessary to attempt any detailed argument to prove the great desirability and value of a convenient source of supply of authentic or accurately identified pure cultures of the various organisms with which plant patholo-

[1] Read at the special meeting of the American Phytopathological Society, Berkeley, Cal., August 5, 1915.

gists may be working. The great saving in time and labor which would result if investigators were able at any time to obtain a pure culture, authentic or identified with certainty, of organisms which they were studying, but of whose identity they were not entirely certain, would be ample return for the cost of establishing and maintaining a means of supplying such cultures. Of far greater importance, however, would be the increased accuracy and reliability of the results of pathological and mycological studies. There is probably no active worker in plant pathology who has not at some time felt the need of authentic cultures for comparison with his own. This need has been met in some cases by individual exchanges of cultures. As you probably know, an attempt has already been made in Europe to meet this longfelt want. The Association Internationale des Botanistes undertook this work some years ago and placed it under the immediate direction of Dr. Johanna Westerdijk, the pathologist of the "Willie Commelin Scholten" of Amsterdam. This work is carried on under the title of "Centralstelle für Pilzkulturen." Miss Westerdijk has been very successful in her work and has supplied many cultures to American pathologists. Unfortunately, limitations in funds and assistants prevent her from meeting the great demands and requirements of the pathologists of the world as a whole. The great distances which separate the pathologists of America from the laboratory at Amsterdam make it almost impossible to satisfactorily supply us from that source. To meet the requirements of American pathologists it seems necessary to establish a supply laboratory in this country. Such a laboratory could and should work in active and hearty cooperation with the Centralstelle in Amsterdam and the two laboratories should be of great mutual assistance. Another supply station might very properly be established in Japan. The facilities needed in America are a central supply laboratory which shall make a special effort to secure by collection, purchase or exchange, and maintain for distribution, pure cultures of the various pathogenic organisms and their relatives which are obtainable from the different laboratories and workers, not only in this country but throughout the world. At the same time type cultures or authentic cultures should be permanently preserved by the most suitable method in each case, for purposes of future study and comparison. Sub-cultures from the type or authentic cultures should be made, renewed from time to time, and kept in sufficient quantity to meet the requirements of pathologists. One of the first requirements for the successful maintenance of such a laboratory would be the most active and generous support of pathologists and mycologists in furnishing such cultures as they may possess. Each worker should send to the central laboratory cultures and specimens of any new organisms he may discover or any authentic or

interesting cultures of other organisms. In this way there would be accumulated a large and important collection of specimens and cultures of inestimable value for the present and future.

It is not our purpose to attempt to give a detailed plan of just how such a supply laboratory should be handled, or where, or under what auspices it should be managed. Since the great bulk of the pathological work in America is carried on by the United States Department of Agriculture and the state agricultural college and experiment stations, it would seem natural that such an undertaking should be chiefly controlled by these agencies.

Our purpose in calling attention to the matter at present is to arouse discussion and initiate some action which may lead to the establishment of such a laboratory in this country in the near future. As a step in this direction I would suggest that the Society appoint a committee to consider the subject and make such recommendations as it deems desirable.

BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

NOTES ON SOME NORTH AMERICAN RUSTS WITH CAEOMA-LIKE SORI

C. A. Ludwig

All the genera of North American rusts having caeomoid sori at any stage in the life history have been treated in one or the other of the two rust numbers of the North American Flora which have already been published. Since the publication of these numbers, however, several facts of interest have become known concerning some of these rusts, especially in the genera Coleosporium and Melampsora. In order to record these new facts the writer has made a study, at the suggestion of Dr. J. C. Arthur, of all the North American caeoma-forms of rusts; and the present paper embodies the most valuable new data secured in the study.

The term "caeoma-like" as used in this study has reference to the form of the sorus, rather than to function or accompanying structure, and is applicable to a sorus which has no surrounding structure limiting it or preventing true coalescence, and which has the spores borne in chains. A sorus surrounded by paraphyses, as in the aecia of Phragmidium and Earlea, which are often called caeomoid, is not therefore a caeoma-like sorus in the present sense, because the paraphyses persist even in case of apparent coalescence and separate the sori from each other. The rusts which are included as having caeoma-like sori are as follows: uredinia in Coleosporium, twenty-five species; aecia in Melampsora and undistributed Caeoma, eleven species; aecia in Neoravenelia, one species; telia in Gymnoconia, two species; aecia in Eriosporangium (in part), five species. Other species of Eriosporangium are not included because fragile peridia are present or the aecia are unknown. The following key will serve to distinguish the different groups.

KEY TO THE GROUPS OF RUSTS WITH CAEOMA-LIKE SORI

Sori not accompanied by pycnia..... Group I, *Coleosporium*
Sori normally accompanied by pycnia
  Spore walls finely verrucose; spores broad
    Sori from a limited mycelium
      Fungus not causing notable hypertrophy;
        sori yellow to white..... Group II, *Melampsora*, etc.[1]

[1] Unconnected species of *Caeoma*, such as *C. conigenum* and *C. strobilinum*.

Fungus causing conspicuous hypertrophies; sori densely crowded on these areas, reddish brown	Group III, *Neoravenelia*
Sori from a diffused mycelium	Group IV, *Gymnoconia*
Spore walls rather coarsely verrucose; spores usually long and narrowed at one or both ends	Group V, *Eriosporangium*

No new material of much importance was secured concerning the last three of the groups of rusts just mentioned, and they will not be given further treatment. The first two in the list, however, deserve further discussion.

GROUP I. COLEOSPORIUM

Group I includes the uredinia of the genus Coleosporium. The rusts of this genus have all four of the spore forms in the life cycle and are heteroecious. The pycnia and aecia occur as species of the form genus Peridermium on pine leaves. The uredinia and telia occur on various broad-leaved plants. For a long time the greatest taxonomic problem in connection with this genus in North America has been to match up the large number of recognized species of Coleosporium with the far fewer species of Peridermium. One of the possibilities is that not all the species of Peridermium have yet been described. The likelihood of this is especially great in Mexico and Central America, regions which are as yet very imperfectly explored botanically. There is another possibility, however, which amounts almost to a demonstrated fact; and this is that several of the species as now accepted are not true species in a restricted sense of the term, but are identical with one another except for host specialization, and may be considered more properly as biological races. An important experimental contribution to this belief is some recently published culture work by Klebahn.[2]

In this work Klebahn shows that *Schizanthus Grahami*, a solanaceous plant from South America, is susceptible to the following European species of Coleosporium when inoculated with urediniospores: *C. Euphrasiae* on Alectorolophus, *C. Melampyri* on Melampyrum, *C. Campanulae* on several species of Campanula, *C. Tussilaginis* on Tussilago, and *C. Senecionis* on Senecio. The last three species were also able to infect *Tropaeolum minus*. As a conclusion from these results, it is clear that in the genus Coleosporium, as in many others, the presence of bridging hosts shows the very close relationship or practical identity of some forms now considered distinct species. Such being the case, further cross inoculation work of this nature must inevitably reduce very considerably the number of recognized species of this genus. The work on the genus

[2] Zeitschr. Pflanzenkr. **24**: 14—20. 1914.

Coleosporium, here reported is an attempt to arrange the species according to morphological characters and thus to group together those which have close relationship or practical identity. The key to the species of Coleosporium which follows is based on the results of this work. The characters utilized in the key are drawn chiefly from the uredinia. Because of their extreme likeness in this genus, the telia are not of much service in distinguishing species.

Key to the Species of Coleosporium

Uredinospore wall thickened unequally
- Thickening located at the apex of the spore
  - Spores narrowly ellipsoid ..... *C. delicatulum*
  - Spores broadly ellipsoid ..... *C. Vernoniae*
- Thickening located at one side of the spore ..... *C. Madiae*

Uredinospore wall uniformly thickened
- Wall thick, over 2 μ
  - Wall very thick, 3 to 5 μ ..... *C. ribicola*
  - Wall less thick, 2 to 3 μ
    - Spores small, 16 to 19 x 20 to 26 μ ..... *C. inconspicuum*
    - Spores larger, 19 to 27 x 23 to 33 μ. *C. Viburni* group, including ..... I. *C. Viburni*, *C. arnicale*
- Wall variable, usually about 1.5 to 2 μ thick, rarely 2.5 μ
  - Apical wall of teliospore swelling to 30 μ or more (Occasionally less, teliospores not known in one species)
    - Warts of uredinospores broad and low ..... *C. apocynaceum*
    - Warts of uredinospores finer and more slender
      - Wall very finely and very closely verrucose, *C. Ipomoea* group, including ..... II. *C. Ipomoeae*, *C. Solidaginis*, *C. Laciniariae*
      - Wall markings a little coarser *C. Helianthi* group, including ..... III. *C. Helianthi*, *C. anceps*
      - Wall rather sparsely verrucose
        - Spores rather small, 13 to 20 x 19 to 30 μ. *C. Elephantopodis* group, including ... IV. *C. Elephantopodis*, *C. Eupatorii*
        - Spores larger, 18 to 23 x 26 to 35 μ ..... *C. Steviae*
  - Apical wall of teliospores swelling 20 to 30 μ
    - Tubercles of uredinospores low ..... *C. Terebinthinaceae*
    - Tubercles of uredinospores more slender
      - Urediniospores large, 14 to 22 x 26 to 43 μ ..... *C. paraphysatum*
      - Urediniospores smaller, 15 to 19 x 19 to 24 μ .... *C. Sonchi-arvensis*
  - Apical wall of teliospore swelling 20 μ (average) or less.
    - Tubercles of uredinospores usually low
      - Teliospores comparatively short, 38 to 58 μ .... *C. Begoniae*
      - Teliospores longer, 45 to 85 μ
        - Tubercles of uredinospores very fine, *C. Campanulae* group, including ..... V *C. Campanulae*, *C. occidentale*

Tubercles of uredinospores broader.....*C. Dahliae*
Tubercles of uredinospores more cylindrical
Urediniospores comparatively large, 19 to 24 x 26 to 37 μ and teliospores comparatively small, 10 to 13 x 26 to 33 μ..... *C. Plumierae*
Urediniospores smaller, 20 to 24 x 20 to 28 μ, and teliospores larger, 14 to 20 x 24 to 45 μ.....*C. Mentzeliae*

(*Coleosporium Bletiae* Dietel, which was collected once in California, is now undoubtedly absent from North America, and so is not included in this list.)

The rust on Campanula and that on Senecio, both of which have been collected in America (although the latter only once) are included in the report by Klebahn mentioned above, and are therefore combined here, the name being *Coleosporium Campanulae* (Pers.) Lév. No other combinations are made, although the following probable identities are suggested from the morphological studies:

(I) *C. Viburni* and *C. arnicale*. These two forms are usually separated on the basis of the character of the spore wall markings, the first being comparatively coarse and rough and the second finer and more even. Aside from the fact that they inhabit different hosts the difference just mentioned is about all that can be made out, and this difference is little if any greater than one would expect to be induced by the different hosts. If the two should prove to be identical, as suggested, the name for both would be *Coleosporium Viburni* Arth.

(II) *C. Ipomoeae*, *C. Solidaginis*, and *C. Laciniariae*. These three forms are very much alike, both as to uredinia and as to telia. The urediniospores are evenly and very finely verrucose, especially in the case of the first two. The markings in the case of *C. Laciniariae* are a bit coarser and rougher, approaching in this respect the species in the next group. Indeed, it is possible that the two groups should be combined, but the differences are great enough to make it seem unlikely that they should be so disposed. Should these three forms prove to be identical, the proper name would be *Coleosporium Ipomoeae* (Schw.) Burrill.

(III) *C. Helianthi* and *C. anceps*. The evidence for considering these two forms as separate species lies in a slight difference in shape and spore surface of the urediniospores. The spores of the former are more generally globoid in shape and have more slender papillae. In all other characters they seem to agree well, and they occur on the same host genus, so that it seems very likely that they are to be considered identical. The name, in case of identity, should be *Coleosporium Helianthi* (Schw.) Arth.

(IV) *C. Elephantopodis* and *C. Eupatorii*. These two forms are suggested to belong together on the basis of a close resemblance of the uredi-

niospores only. They are much alike in size, shape, wall thickness, and wall markings. It has not been possible to compare teliospores, however, as none are known as yet for *C. Eupatorii*. The name, should they prove to be identical, will be *Coleosporium Elephantopodis* (Schw.) Thüm.

The three groups just discussed (II, III, and IV) differ from one another chiefly in the character of spore wall markings, and the variation from one to the other is so gradual as to make it very difficult to decide where to draw the line between groups. It is not altogether improbable, therefore, that when culture work shall have settled the question definitely the grouping of these forms will be somewhat different from that given above.

(V) *C. Campanulae* and *C. occidentale*. *C. occidentale* is a western form on Senecio which exhibits some differences from the European form on Senecio. The fungus as a whole has a more robust character than is found in the European form. The urediniospores are larger, the walls a little thicker, and the markings are coarser. Aside from these things it agrees very well with the other. Only one collection of the western form is at hand, and it is possible that it is an exception in this respect. At any rate, the difference is such as would be induced by a robust, coarse habit in the host. Should they prove to be identical, the name *Coleosporium Campanulae* (Pers.) Lév. should be used.

If this set of suggestions as to identities should prove correct, the number of North American species of Coleosporium would be reduced from twenty-five to nineteen, a number which approaches somewhat more nearly the number to be expected, but which seems even yet too large, as according to Arthur and Kern,[3] there are in North America eleven recognized foliicolous species of Peridermium on pine. The difference of eight species will probably be accounted for by the discovery of other telial combinations not yet suggested, or by the discovery of more undescribed species of Peridermium, or by both means. Cross inoculation work with urediniospores is very important in this group.

GROUP II. MELAMPSORA AND CAEOMA

Group II includes the aecia of the genus Melampsora and in addition a number of undistributed aecia of the same general character occurring on Pinaceae. The genus Melampsora is characterized by having a full life-cycle, of which the aecia are caeomoid and the telia waxy, with single-celled teliospores compacted into a layer. The pycnia are either subcuticular or subepidermal. The last three species included in the group are quite different in some characters from the others and probably have

[3] Mycologia **6**: 109—138. 1914.

some other telial connection than Melampsora. Eleven American species are recognized, one on Grossulariaceae, one on Saxifragaceae, and the rest on Pinaceae.

The following key will serve for the identification of species in this group:

Key to the Species of Melampsora and Caeoma

Pycnia subcuticular, wholly above the epidermis
- Spores globoid to ellipsoid
  - Pycnia hemispherical
    - Sporophyte occurring on Salix ..... *M. Bigelowii*
    - Sporophyte occurring on Populus ..... *M. Medusae*
  - Pycnia disk-shaped to conical ..... *M. Abietis-canadensis*
- Spores broadly ellipsoid ..... *M. albertensis*

Pycnia subcuticular, when mature located just above the mesophyll tissue and occupying the place of a number of disintegrated epidermal cells ..... *M. arctica*

Pycnia subepidermal
- Spores ellipsoid to globoid
  - Wall moderately thin, 1.5 to 2.5 μ ..... *M. confluens*
  - Wall thicker, 2 to 3 μ ..... *M. alpina*
- Spores globoid
  - Wall thin, uniform ..... *M. Lini*
  - Wall thicker, thickened at apex ..... *C. dubium*

Pycnia subcorticular
- *Bubakia* (?) group, including ..... *C. conigenum*, *C. strobilinum*

The following species of this group are of interest for one reason or another and deserve further consideration:

(I) *Melampsora Bigelowii* Thüm., with sporophytic stage on Salix, and *M. Medusae* Thüm., with the same stage on Populus, are two species both of which have pycnia and aecia on leaves of Larix. These latter sori are so nearly alike that it is impossible with our present knowledge to tell them apart by morphological characters. There seems to be no chance, however, that they are merely races of the same species because there are very evident structural differences in the urediniospores. The urediniospores of *M. Medusae* are larger than those of the other, usually longer for their thickness, are flattened on two opposite sides in a very large percentage of the spores, and have the wall thickened on the flattened sides; while the urediniospores of *M. Bigelowii* are regular in shape and have walls of uniform thickness.

(II) Another species of interest in this connection is the one on *Tsuga canadensis* connected by Fraser[4] with uredinia and telia on Populus. This species is herewith discussed somewhat in detail.

[4] Mycologia **4**: 188. 1912. Ibid. **5**: 238. 1913.

Melampsora Abietis-canadensis (Farl.) n. comb.

Caeoma Abietis-canadensis Farl. Proc. Am. Acad. **20**: 323. 1885.
Peridermium fructigenum Arth. Bull. Torrey Club **37**: 578. 1910.
Caeoma Tsugae Spaulding, Sci. n. s. **33**: 194. Hyponym. 1911.

ON PINACEAE:

Tsuga canadensis (L.) Carr. (*Abies canadensis* Michx.), Chebacco Lake, Massachusetts, June, 1883, *A. B. Seymour;* Nova Scotia (*W. P. Fraser,* Pictou, June 30, 1911 and July 18, 1912, Truro, July 10, 1910); Quebec (*Fraser,* Hudson, 1913); Wisconsin (*J. J. Davis,* Ellison Bay, July 14, 1913, Mellen, July 14, 1908, Fish Creek, July 5, 1913); Connecticut (*Perley Spaulding,* East Granby, June 21, 1908, *114,* Granby, June 26, 1909, *2060*). The collection issued as Barth. Fungi Columb. *3103* and N. Am. Ured. *103*, and said to be *Caeoma Abietis-canadensis* on *Tsuga heterophylla* is *C. dubium*, and therefore does not belong here.

DISTRIBUTION: Connecticut to Nova Scotia and westward to northern Wisconsin.

EXSICCATI: Ell. & Ev. Fungi Columb. *1882*.

The type collection (the first one mentioned above), which is on leaves, was issued as no. *1882* of the second series of Ellis & Everhart's N. Am. Fungi, where it is credited to Dr. W. G. Farlow, who communicated the material to the publishers. Part of the type is in the Arthur herbarium.

The first Tsuga rust on cones brought to the notice of the workers in this laboratory was the East Granby collection by Spaulding. In the examination of this material some structures were found which were interpreted as peridial cells and the species was published as *Peridermium fructigenum*. Later, Spaulding published the same species as *Caeoma Tsugae*, without, however, giving a description. Since then two such collections by Fraser have been received, one of which he had connected by field evidence with Melampsora on Populus, and the other of which was a culture from teliospores on Populus. A study of these four collections shows that they are the same species, and are caeomoid in character. The cells which were interpreted as peridial cells might well be large abnormal spores.

The aecia and telia of this rust occur on Populus, and were formerly included in *Melampsora Medusae*. The writer has studied Fraser's collections in comparison with the wealth of material in the Arthur herbarium referred to *M. Medusae*. This study has shown that the species is distinct from *M. Medusae*, and can be recognized in the uredinial stage by the morphological characters of the spores. The spores are small, 13 to 18 by 16 to 24 μ (about the size of the smallest ones in *M. Medusae*), and uniformly and broadly obovoid to globoid, as contrasted with an abundance of long narrow spores in the other species. The wall is uniform in thickness or only slightly thickened laterally, whereas in *M.*

Medusae the wall is regularly flattened and much thickened on two opposite sides. The following hosts and localities are here given for the uredinial and telial stage:

ON SALICACEAE:

Populus candicans Ait., Connecticut, Massachusetts, Michigan; *P. deltoides* Marsh., Indiana; *P. grandidentata* Michx., Connecticut, Indiana, Michigan, Ohio, Nova Scotia; *P. heterophylla* L., Indiana; *P. Sargentii* Dode, Iowa; *P. tremuloides* Michx., Indiana, Maine, Ohio, Tennessee, Ontario.

EXSICCATI: Kellerm. Ohio Fungi *144, 145;* Barth. N. Am. Ured. *111.*

(III) *Melampsora arctica* Rostr. has aecia on *Abies balsamea* (L.) Mill. and *A. concolor* Lindl., with a distribution from Nova Scotia and New Hampshire westward to and extending southward in the Rockies. The aeciospores on *Abies concolor* are somewhat coarser in character than those on *Abies balsamea;* i.e., they have thicker cell walls and coarser markings on the walls and are somewhat larger than the others. However, there seems to be no doubt that the two forms are the same species, although the rust has not yet been cultured on *A. concolor,* because the variation mentioned is the kind which such host differences usually induce in a rust, and because they both exhibit the same peculiar kind of pycnia as here described. The pycnia are subcuticular, but instead of being situated on top of the epidermal cells, as is usual with subcuticular pycnia, they are situated in a cavity in the epidermis caused by the complete disintegration of a number of cells. Because of this habit they are very easily interpreted as being subepidermal.

(IV) Another interesting and apparently undescribed rust is one on *Tsuga heterophylla* from the northwest. It has been impossible with the dried specimens at hand to determine whether the spores are catenulate or pedicellate. They are borne at a definite distance from the hymenium as if pedicellate, and it has been impossible to demonstrate any chains, even of immature spores. On the other hand it has been equally impossible to demonstrate the presence of pedicels, and it is easy to see how the appearance described might be produced by a sorus of catenulate spores in which the apical spore of each chain matures and becomes detached before the next one enlarges appreciably. Furthermore, the sori are accompanied by pycnia, showing that they function as aecia; and the spore walls are verrucose, indicating the catenulate arrangement. The writer does not know of any rust having spores functioning as aeciospores which are both verrucose and pedicellate. It is, therefore, with a fair degree of confidence that this species is classed with Caeoma instead of with Uredo, although more material is necessary in order to determine the point definitely.

On account of the subepidermal pycnia this species is rather easily distinguished from *Melampsora Abietis-canadensis* and *Uredo Holwayi* on the same host, both of which have subcuticular pycnia. *U. Holwayi* is distinguishable further by having echinulate spore walls and by having the sorus surrounded by a pseudoperidium of paraphyses. The alternate stage of the undescribed species is likely some Melamspora-like rust from the northwest which is perhaps not yet described. It is not likely a genuine Melampsora, however, as all of the species of Melampsora known to have aecia on Pinaceae are characterized by subcuticular pycnia, whereas this has subepidermal pycnia.

A description is here appended:

Caeoma dubium n. sp.

O. Pycnia hypophyllous, rather numerous, scattered, noticeable, subepidermal, golden brown, hemispherical to disk shaped, 80 to 115 μ wide by 50 to 80 μ high; ostiolar filaments absent.

I. Aecia hypophyllous in two longitudinal lines, subepidermal, oblong, 0.2 to 0.4 mm. wide by 0.3 to 0.8 mm. long, not crowded, pulverulent, light yellow when dry, early naked, ruptured epidermis evident; aeciospores broadly ellipsoid to globose, 15 to 21 by 15 to 22 μ; wall colorless, 1.5 to 2.5 μ thick, often thickened above, 3 to 4.5 μ, prominently and very closely verrucose.

ON PINACEAE:

Tsuga heterophylla (Raf.) Sarg., Bainbridge Island, Kitsap Co., Washington, July 17, 1909, *E. Bartholomew 4087*, type (in Barth. N. Am. Ured. *103*, Fungi Columb. *3103*); Grizzly Creek Trail, Beaver River Valley, British Columbia, July 27, 1907, E. W. D. Holway.

DISTRIBUTION: Northwestern United States and western Canada.

(V) *Caeoma conigenum* Pat. and *C. strobilinum* Arth. are two forms which are very similar to each other and may ultimately be found to be identical. *C. strobilinum* was originally separated from the other on the basis of having much thinner and less verrucose spore walls. A reexamination of spores from the type material of both does reveal that, in general, the spore walls of *C. conigenum* are the thicker and more coarsely verrucose of the two, but that many spores in the type of *C. strobilinum* nearly or quite equal them in these respects. In size and shape of spores and in distribution of markings they are practically identical. However, the material of *C. conigenum* at hand is only fragmentary, so that a careful comparison of other characters could not be made. Because of this, therefore, and because the most likely alternate stage, Bubakia on Croton, is represented by two species, one of which is in the region of *C. conigenum* and the other in the region of *C. strobilinum*, the writer considers that it is not wise at this time to combine the two.

PHYTOPATHOLOGICAL NOTES

Sugar beet curly-top. The writer has read with much interest the article entitled "New Light on Curly-Top of the Sugar Beet," on page 103 of the April number of PHYTOPATHOLOGY. The point that appears new to Messrs. Smith and Boncquet is the finding of lesions containing bacteria in the diseased beets, though inoculations with pure cultures of these bacteria gave negative results. Miss Nellie A. Brown, of the Pathological Laboratory, Bureau of Plant Industry, and myself have frequently observed the lesions or pockets containing bacteria and have repeatedly isolated an organism from curly-top beets, but, like the authors of the article mentioned, we have not been able to reproduce the symptoms by inoculation with artificial cultures. Until this is done, we can hardly say that we have any new light on the subject, but rather that we have a "lead" that may eventually throw some light upon the real cause of curly-top. It seems to me decidedly misleading to herald as "new light" any discovery of this kind until we know and can demonstrate that it has or has not some direct relation to the disease under investigation.

So far as has been determined *Eutettix tenella* appears to be the only carrier of the disease-producing agent, and yet there seem to be conditions under which this insect may appear to infest the beet plant without producing curly-top, even though the external conditions surrounding the plant seem to be favorable for the development of the disease. Are the beets sometimes resistant to the disease-producing agent or is *Eutettix tenella* sometimes free from the exciting agent? There are also "leads" that may help us to solve the problem, but until we can reproduce the disease at will we must remain in the dark as to its real cause. Furthermore, until we know the real cause of curly-top there can be but faint hope of solving the more important economic problem of its control.

C. O. TOWNSEND

Florida plant board. The legislature of the State of Florida has created a Plant Board, which now has the same personnel as the Board of Control of the State Institutions for Higher Learning, charged with the control of plant diseases and insect pests. For the ensuing biennium there is appropriated the sum of $125,000 for the campaign against citrus canker and $70,000 for other pests. Prof. Wilmon Newell, formerly entomologist at the Texas Experiment Station, has been appointed Plant Commissioner,

Mr. E. W. Berger, entomologist, Dr. R. A. Jehle, formerly of the Cuban Experiment Station, plant pathologist, and Mr. F. M. O'Byrne, Inspector of Nurseries.

Personals. Dr. Howard S. Reed, formerly head of the Department of Plant Pathology and Bacteriology in the Virginia Polytechnic Institute and Plant Pathologist in the Virginia Agricultural Experiment Station, removed to Riverside, California, on July 1, to accept a position as Plant Pathologist and Bacteriologist of the Citrus Experiment Station at that point. He is succeeded by Dr. F. D. Fromme, formerly Assistant in Botany in the Indiana Agricultural Experiment Station.

Prof. H. S. Jackson, formerly Botanist and Plant Pathologist of the Oregon Agricultural Experiment Station, Corvallis, Oregon, assumed his duties on September 1 as Chief in Botany at the Agricultural Experiment Station of Purdue University, La Fayette, Indiana. Dr. J. C. Arthur, who was head of this Department, has retired under the Carnegie Foundation for the Advancement of Teaching.

Mr. Paul A. Murphy, formerly of the Department of Agriculture and Technical Instruction for Ireland and more lately engaged in post-graduate work in the Department of Plant Pathology of Cornell University, has been appointed as Assistant Pathologist in the Division of Botany of the Department of Agriculture of Canada and will be stationed at the Experimental Farm at Charlottetown, Prince Edward Island. Mr. G. C. Cunningham, formerly Assistant Plant Pathologist at the Vermont Agricultural Experiment Station, has accepted a similar position with headquarters at Fredericton, New Brunswick.

Dr. F. Kølpin Ravn of the Danish Royal Landbøhjskolens, arrived at New York on May 6, having made the trip from Denmark on the Danish-American ship Helig Olaf. On the seventh of May he delivered an address at Rutgers College, New Brunswick, New Jersey. He then visited successively Massachusetts Agricultural College, Amherst, Massachusetts; Pennsylvania State Agricultural College, State College, Pennsylvania; Cornell University, Ithaca, New York; Purdue University, La Fayette, Indiana; Wisconsin University, Madison, Wisconsin; University of Nebraska, Lincoln, Nebraska; and Kansas Agricultural College, Manhattan, Kansas. At each of these different colleges one or more of the following lectures were delivered:

(1) The development of plant pathology and modern agricultural progress in Denmark.

(2) Heredity and plant diseases.

(3) On the possibility of determining losses in cereals due to fungous diseases.

(4) The possibilities of indemnification for the loss caused by diseases transmitted through seed.

The last lecture was delivered at Manhattan, Kansas, on the twenty-second of May.

Following that date Doctor Ravn visited the United States and state experiment stations at Tucson and Yuma, Arizona; Berkeley and Medford, California; Corvallis and Moro, Oregon; Bellingham, Spokane, and Pullman, Washington; Bozeman, Montana; Aberdeen, Idaho; Brigham and Logan, Utah; Fort Collins, Greeley, and Akron, Colorado; Madison, Wisconsin; Minneapolis, Minnesota; Fargo, North Dakota; and Brookings, South Dakota. He also visited Indian reservations in Arizona and many private farms and grain fields along the route, and attended the Interstate Cereal Conferences at Berkeley, Davis, and Chico, California, from June 2 to 4 inclusive, returning to Washington on July 18.

An informal reception was tendered Doctor Ravn on Monday evening, July 19, by Mr. M. A. Carleton, of the Bureau of Plant Industry, and on Thursday evening, July 22, the Botanical Society of Washington gave a dinner in his honor at the Cosmos Club in Washington. While on his western trip Doctor Ravn discovered the yellow leaf rust of wheat (*Puccinia glumarum* Eriks. and Henn.) in a field near Sacaton, Arizona. On August 9 to 11 inclusive he participated in a three days' collecting trip at Ithaca, New York, and on August 16 to 18 he visited Aroostook County, Maine, where he participated in a conference on potato diseases held at the field laboratory of the Bureau of Plant Industry, at Presque Isle. He sailed from New York for the West Indies on August 19 and after a sojourn of two weeks returned to Copenhagen by way of New York.

Dr. Otto Appel sailed from New York for Bergen, en route to Germany, on August 14, and arrived safely at his destination.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

June–July, 1915

Appel, Otto. Leaf roll diseases of the potato. Phytopathology **5,** no. 3: 139–148. June, 1915.

Published also in Rpt. Iowa State Hort. Soc. **49** (1914): 203–211. 1915.

Arthur, Joseph Charles. Uredinales of Porto Rico based on collections by F. L. Stevens. Mycologia **7,** no. 4: 168–196. July, 1915.

Ashby, S. F. Coconut diseases in Jamaica. Jour. Jamaica Agr. Soc. **19,** no. 5: 165-168. May, 1915.

Bud rot, leaf diseases, root disease, dwindling or pencil-point, stem disease.

Babcock, D. C. A new scarlet oak disease. Phytopathology **5,** no. 3: 197. June, 1915.

Botryodiplodia sp.

Baker, Carl Fuller. A review of some Philippine plant diseases. Phil. Agr. and Forester **3,** no. 7: 157–164. 1914.

Barrett, J. T. Some observations on wither-tip in 1914. Proc. 45th Fruit Growers' Conv. California **1914:** 242–244. 1915.

Colletotrichum gloeosporioides.

Discussion, p. 243–244.

Baun, R. W. de. Some common potato diseases. To be seen at blooming time. Rural New Yorker **74,** no. 4314: 889–890. July 10, 1915.

Bondar, Gregorio. Heterodera radicicola . . . sobre o parasitisme do "Heterodera radicicola" nos cafeeiros. Bol. Agr. [São Paulo] **16,** no. 4: 329–330. Abril, 1915.

Brown, Theodore. Potatoes without blight. Proc. New Jersey State Hort. Soc. 40th Ann. Sess. **1914:** 53–57. 1915.

Discussion, p. 55–57.

Bryce, P. I. Apple leaf-spot or black rot canker. 7th Ann. Rpt. Quebec Soc. Prot. Plants **1914/15:** 86–90, 3 fig. 1915.

Sphaeropsis malorum.

California. Laws, Statutes, etc. Uniform horticultural laws. Mo. Bul. State Com. Hort. [California] **4,** no. 7: 318–320. July, 1915.

An act . . . in relation to the establishment of quarantine against infectious plant diseases; State quarantine order.

Carter, C. N. A powdery mildew on citrus. Phytopathology **5,** no. 3: 193–196, 1 fig., pl. 12. June, 1915.

Oidium tingitaninum sp. nov.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Coe, H. S. Apple blight. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 184. 1914.

Bacillus amylovorus.

——— Apple scab. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 10–11. 1914.

Venturia pomi.

——— Black rot of apples. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 95–96. 1914.

Sphaeropsis malorum.

——— Plum pockets. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 94–95. 1914.

Exoascus pruni.

——— Potato scab. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 35–36. 1914.

Oospora scabies.

Compere, George. Blight-resistant pear stocks. Mo. Bul. State Com. Hort. [California] **4**, no. 7: 313–314, fig. 67–68. July, 1915.

Chinese wild pear resistant to blight.

Cook, Melville Thurston. Common diseases of apples, pears and quinces. New Jersey Agr. Expt. Sta. Circ. 44, 20 p., 18 fig. [1915].

——— Common diseases of the peach, plum and cherry. New Jersey Agr. Expt. Sta. Circ. 45, 16 p., 10 fig. [1915.]

——— [Some orchard diseases prevalent in New Jersey in 1913.] Proc. New Jersey State Hort. Soc. 39th Ann. Sess. **1913**: 52–59. 1914.

Coulter, John Merle. Charles E. Bessey. Science n. s. **41**, no. 1060: 599–600. April 23, 1915.

Day, Leonard H. Apricot gummosis and sour sap—report on observations and inoculation experiments, Mo. Bul. State Com. Hort. [California] **4**, no. 7: 330–332. July, 1915.

"Several distinct parasitic diseases in which gummosis is the first externally evident symptom, are commonly classed as sour sap."

Dodge, Bernard Ogilvie. Relationship between Roestelia transformans and R. botryapites. Torreya **15**, no. 6: 133–134. June, 1915.

Edson, Howard Austin. Rheosporangium aphanidermatus, a new genus and species of fungus parasitic on sugar beets and radishes. Jour. Agr. Research **4**, no. 4: 279–292, pl. 44–48. July, 1915.

Ellett, Walter Beall, and **Grissom, J. T.** The amount of arsenic in solution when lead arsenate is added to different spray solutions. Virginia Agr. Expt. Sta. Ann. Rpt. **1913/14**: 160–164. 1915.

Issued also as Virginia Agr. Expt. Sta. Tech. Bul. 8.

Elston, Leo Weiss. The resistance of varieties of fruits to injurious insects and diseases. Proc. New Jersey State Hort. Soc. 39th Ann. Sess. **1913**: 189–191. 1914.

Eriksson, Jakob. International phytopathologic collaboration. Work begun in Europe—will it be prosecuted in America? Phytopathology **5**, no, 3: 133–138. June, 1915.

European literature, 1890–1914, p. 137–138.

Fawcett, Howard S. Melaxuma of the English walnut. Proc. 45th Fruit Growers' Conv. California **1914**: 216–218. 1915.

Discussion, p. 217–218.

Fawcett, Howard S. Pointers in fungi. Proc. 45th Fruit Growers' Conv. California **1914**: 309–312. 1915.

Discussion, p. 311–312.

Life of fungi; control of fungus diseases.

Foster, S. W. Combination spraying experiments for the control of mildew and leaf hoppers on grape vines. Mo. Bul. State Com. Hort. [California] **4**, no. 5/6: 250–253. May/June, 1915.

Franklin, Henry J. Report of cranberry substation for 1914. Massachusetts Agr. Expt. Sta. Bul. 160: 91–117. 1915.

Frost protection, p. 93; fungous diseases, p. 94–100.

Fraser, W. P. The cereal rusts. 7th Ann. Rpt. Quebec Soc. Prot. Plants **1914/15**: 116–120. 1915.

Fyles, Faith. A preliminary study of ergot of wild rice. Phytopathology **5**, no. 3: 186–192, pl. 11. June, 1915.

New species—name not assigned.

Giddings, Nahum James, and **Berg, Anthony.** Apple rust or cedar rust in West Virginia. West Virginia Agr. Expt. Sta. Circ. 15, 16 p., illus. 1915.

Methods of control, p. 8–16.

Gladwin, F. E. Observations relative to an obscure grape affection. Phytopathology **5**, no. 3: 169–174, 1 fig. June, 1915.

Cause unknown. Trouble is connected in some way with the relationship of roots to the soil.

Gloyer, Walter O. Ascochyta clematidina, the cause of stem-rot and leaf-spot of clematis. Jour. Agr. Research **4**, no. 4: 331–342, pl. 50–54. July, 1915.

Grossenbacher, John Gasser. Some neglected phases of phytopathology. Phytopathology **5**, no. 3: 155–162. June, 1915.

Influence of environment on susceptibility to plant diseases.

Güssow, Hans Theodor. The control of potato diseases. Canada Dept Agr. Expt. Farms Div. Bot. Circ. 9, 6 p. 1915.

Published also in 7th Ann. Rpt. Quebec Soc. Prot. Plants **1914/15**: 43–49, illus. 1915.

Harter, Leonard Lee, and **Tillotson, Ethel Content Field.** Experiments on the susceptibility of sweet potato varieties to stem rot. Phytopathology **5**, no. 3: 163–168. June, 1915.

Fusarium hyperoxysporum Wr. and *F. batatatis* Wr.

Hecke, G. H. The future of county horticultural commissionership. Proc. 45th Fruit Growers' Conv. California **1914**: 298–301. 1915.

Hedgcock, George Grant. Notes on some diseases of trees in our national forests. V. Phytopathology **5**, no. 3: 175–181. June, 1915.

Species of Razoumofskya [Arceuthobium] attacking Gymnosperms; species of Phoradendron attacking Angiosperms; species of Phoradendron attacking Gymnosperms.

For parts I-IV see previous lists.

Hesler, Lexemuel Ray. Apple cankers and their control. New York Cornell Agr. Expt. Sta. Circ. 28: 17–28, 16 fig. 1915.

Hewitt, Joseph Lee. An unknown disease of the apple. Proc. Arkansas State Hort. Soc. 31st/32d Ann. Meetings **1912/13**: 25. 1914.

No fungi and no bacteria have been found in connection with this disease.

Hoyt, A. S. Depot inspection. Proc. 45th Fruit Growers' Conv. California **1914**: 287–289. 1915.

Hoyt, A. S. Horticultural quarantine and the parcel post. Proc. 45th Fruit Growers' Conv. California **1914**: 161–165. 1915.

Hubert, Ernest E. A new Macrophoma on galls of Populus trichocarpa. Phytopathology **5**, no. 3: 182–185, 3 fig. June, 1915.

Macrophoma tumefaciens Shear n. sp.

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Orders made under this law for dealing with Panama disease of bananas, Bonnygate disease of bananas, and bud rot disease of coconuts.

——— Protection from disease plants law. Jour. Jamaica Agr. Soc. **19**, no. 7: 254–257. July, 1915.

Jones, Frank. [Experiments in spraying potatoes.] Proc. New Jersey State Hort. Soc. 40th Ann. Sess. **1914**: 57–59. 1915.

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Korstian, Clarence F. Pathogenicity of the chestnut bark disease. Forest Club Ann. **6**: 45–66, 5 pl. 1915.

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Kunkel, Louis Otto. A contribution to the life history of Spongospora subterranea. Jour. Agr. Research **4**, no. 3: 265–278, pl. 39–43. June, 1915.

Martin, George W. Spraying experiments with tree fruits. Proc. New Jersey State Hort. Soc. 40th Ann. Rpt. **1914**: 168–173. 1915.

Discussion, p. 173–178.

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REPORT OF SPECIAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY AND THE PACIFIC DIVISION, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA, AUGUST 3 AND 5, 1915

Addresses of welcome were delivered by Dr. Herbert J. Webber, Director of the Citrus Experiment Station and Dean of the Graduate School of Tropical Agriculture, Riverside, California, and by Professor R. E. Smith, President of the Pacific Division of the Society.

Dr. Haven Metcalf responded for the society.

The sessions were presided over by Dr. Haven Metcalf, in the absence of the President and Vice-President of the American Phytopathological Society, and Professor R. E. Smith, President of the Western branch; by Professor R. E. Smith, and by Professor H. S. Jackson, newly elected President of the Western branch, respectively. The attendance at the three sessions varied from forty to fifty persons.

The following programme was presented:

International phytopathology. Otto Appel, *Dahlem, near Berlin, Germany.*

Read by Dr. C. L. Shear, to be published in full in Phytopathology.

Pythiacystis infection of deciduous nursery stock. E. H. Smith, *University of California, Berkeley.*

"A die-back of young deciduous trees, which occurred extensively in northern California the past two seasons, has been traced to a species of Pythiacystis, morphologically identical with *P. citrophthora*. Most of the root stock is apparently immune, but above the bud the bark is infected causing one to several cankers, which often girdle the tree and kill back the whole top. Profuse gumming occurs. The fungus has been isolated from peach, almond, pear and plum, and the disease produced by inoculation in apple, pear, peach, almond, apricot, prune and cherry, all from one-year-old stock. Similar cankers have been produced by inoculation with *P. citrophthora* isolated from lemon fruit. A Pythiaceous fungus has been twice isolated from almond cankers, and successfully inoculated into almond, which readily develops an oosporic stage. This has different characters of growth from the original strain, and a less degree of pathogenicity, but may ultimately prove to be the same species."

Two eastern forest diseases which threaten the Pacific States. With lantern. Haven Metcalf, *U. S. Department of Agriculture, Washington, D. C.*

The speaker exhibited lantern slides and specimens of the chestnut bark disease (*Endothia parasitica*) and the white pine blister rust (*Cronartium ribicola*). The danger which these diseases present to the cultivated chestnut of the Pacific States, and to the native stand of five-leaf pines, was indicated. Especially to be considered is the danger to the very valuable species, *Pinus lambertiana* and *P. monticola*. The speaker advocated rigid state quarantines against nursery stock of the genus Castanea, the five-leaf species of pines, and the genus Ribes.

Beet blight. R. E. Smith, *University of California, Berkeley, Cal.*

Specimens of diseased beets were exhibited and the methods being employed in the study of the disease were explained and illustrated. The structure of the dis-

eased beets was discussed and certain peculiarities were described. Possible connection with certain bacteria was suggested and the nature and difficulties of the problem concerned were discussed. In the discussion which followed the paper, Director Ball of Utah and a number of other persons gave their views on certain phases of the problem, especially with regard to the relation of the disease to insects. Mr. August Boncquet of Spreckels, California, gave support to the suggestion that only insects which have been in contact with diseased beets are capable of transmitting the disease.

Forest pathology. E. P. MEINECKE, *U. S. Department of Agriculture, San Francisco.*

A number of forest diseases were exhibited including interesting and important rusts and mistletoes. A number of new hosts were shown in the collection and important, but hitherto not well-known forms were included in the demonstration.

Northwestern apple anthracnose. H. S. JACKSON, *Corvallis, Oregon.*

Materials were shown of the disease in various forms and the technical phases, particularly cultural work and cross-inoculations with the different spore forms were discussed as well as the economic status of the disease.

Apple mildew. W. S. BALLARD, *U. S. Department of Agriculture, Watsonville, Cal.*

The nature of apple mildew was explained briefly and some account of the history of the efforts which have been made to discover effective control measures was given. Use of colloidal sulphur, prepared by dissolving sulphur in melted rosin, grinding and putting into ammonia water and diluting, was described. The difficulties involved in the use of sulphur in the California coast districts on account of the danger of injury to the trees were discussed and the reasons for the use of unusually dilute spray formulas were described.

Mottled leaf of citrus. J. T. BARRETT, *Riverside, Cal.*

Professor Barrett reviewed the main features of the disease and showed typical specimens. No specific cause has been discovered and the disease is still classed as a physiological disease. The diseased leaves contain more starch than normally on account of defective translocation and apparently also an excess of nitrogen. Some relation appears to have been discovered between fertilization with nitrate of soda without the addition of vegetable material and mottled leaf, but it was pointed out that this is probably not a direct effect of the materials used but of the soil condition produced, since in plots in which liberal use had been made of vegetable material, the disease has not appeared. The disease is being studied at Riverside from all possible points of view and is being treated as a Station problem and not exclusively by any one department. The possibility of an infectious chlorosis is also being investigated. In the discussion Professor F. S. Earle pointed out that there are probably two distinct types of mottled leaf in Cuba and the Isle of Pines, arising from what is probably a specific disease of the small roots and from general unfavorable soil conditions.

Bacterial canker of cherry and filbert disease. H. P. BARSS, *Corvallis, Ore.*

Griffin has already shown the bacterial origin of the bud blight in cherries. The identity of cause for bud blight and body canker was shown by the speaker by means of inoculations made in the fall. Inoculations at other seasons were not successful. The disease is most destructive during the first seven or eight years of the life of the tree. It is now largely controlled by planting Mazzard stock and grafting in the limbs of this. Natural cankers have been found in apricot, prune and Simoni plum.

The filbert disease is also caused by bacteria. The organism in this case is yellow and similar to the walnut blight bacterium. A leaf spotting and killing of twigs is produced and cankers are formed, succulent tissue being susceptible.

Crown-rot of fruit trees: Histological studies. J. G. GROSSENBACHER, *U. S. Department of Agriculture, Washington, D. C.*

Read by title.

Some new and old methods in plant pathology. J. FRANKLIN COLLINS, *U. S. Department of Agriculture, Washington, D. C.*

Read by title.

Citrus gummosis and melaxuma. H. S. FAWCETT, *Whittier, Cal.*

These diseases were illustrated by means of lantern slides and brief explanations together with a set of specimens and photographic enlargements. Gummosis is caused by the fungus *Pythiacystis citrophthora* S. and S. and melaxuma by a fungus probably of the genus Dothiorella.

Fruit stain and wither-tip of citrus. J. T. BARRETT, *Riverside, Cal.*

Effects of the fungus, *Colletotrichum gloeosporiodes*, were illustrated on twigs and fruit. Dr. Barrett stated that he did not yet have evidence that the fungus is capable of infecting thoroughly sound and healthy tissue of leaves and twigs but infection of the fruit through germination from appressoria, killing small areas of rind, and later development of the fungus cause serious fruit rotting in addition to the tear-stain marks upon the surface.

Observations on prune rust, Puccinia pruni-spinosae Pers., in Southern California. J. T. BARRETT, *Riverside, Cal.*

The disease caused by *Puccinia pruni-spinosae* has become serious at times in Southern California in apricots and peaches. The characteristic spots and injury to the orchard by defoliation were shown by lantern slides. In some cases, early fall pruning has stimulated fall growth in which foliage remains alive through the winter and rust developed in this has permitted early spring infection with very detrimental effect to the orchards.

Coryneum fruit spot of apricot. J. T. BARRETT, *Riverside, Cal.*

Characteristic spotting was shown with lantern slides. Fruit spot has been confused with other troubles by growers and is not of so universal distribution in apricots as has been supposed. Accordingly, spraying operations have not given satisfaction in all cases.

Walnut blight and crown gall. C. O. SMITH, *Whittier, Cal.*

The symptoms of this disease were illustrated by means of lantern slides and specimens were shown in the laboratory.

Peridermium harknessii Moore and Cronartium quercuum (Berk.). E. P. MEINECKE, *U. S. Department of Agriculture, San Francisco, Cal.*

The results of extensive observations on these rusts and inoculation experiments with the different spore forms were given.

An established Asiatic Gymnosporangium in Oregon. H. S. JACKSON, *Corvallis, Oregon.*

Results of careful studies and cross-inoculations with a newly imported Japanese Gymnosporangium discovered on oriental pears in Oregon were given.

The need of a pure culture supply laboratory for plant pathology in America. C. L. SHEAR, *U. S. Department of Agriculture, Washington, D. C.*

Published in full in this issue of PHYTOPATHOLOGY.

Studies of the Rhizoctonia disease of potatoes. J. H. CORSAUT, *Corvallis, Oregon.*

On account of the seriousness of potato troubles due to Rhizoctonia in the state of Oregon, studies on this disease were undertaken. Affected plants and tubers were

secured from different localities and a large number of different strains of the causal organism were isolated from sclerotia on the tubers, from sterile mycelium on the underground parts of the plant, from basidium-bearing mycelium and from individual basidiospores. The cultural characters of these strains were similar but showed some variation. A splendid development of the typical Corticium (Hypochnus) stage appeared on the stems of young plants grown in sterilized soils from sterilized seed pieces which had been inoculated with pure culture of the organisms isolated from sclerotia, sterile mycelium and single basidiospores. A number of different varieties of potatoes were inoculated with Rhizoctonia, grown under similar conditions and the effects noted. Some varieties proved extremely suceptible while others were rather strongly resistant. It was also found that when grown on sterile raw plugs cut from different varieties of potatoes the fungus developed rapidly on certain varieties and but slowly on others. By artificial means, healthy, Rhizoctonia-free potato plants were made to reproduce both the *aerial potato* condition and the *little potato* condition which are frequent consequences of natural attacks of Rhizoctonia. These experiments indicate that the abnormal effects referred to are purely secondary results of the Rhizoctonia attack caused by interference with the normal process of food storage in the plant.

Studies of Monilia blight of fruit trees. G. B. POSEY, *Corvallis, Oregon.*

Read by H. P. Barss. Very interesting results of cultures and inoculations with a large number of strains, including three distinct forms of Monilia in Oregon, were presented.

A Podosporiella disease of germinating wheat. P. J. O'GARA, *Salt Lake City, Utah.*

"On examining a weak strand of wheat in Salt Lake Valley the trouble was traced back to the seed, the content of the kernels of which were found to have been largely consumed by a dark brown, septate mycelium, which did not appear on the surface. The seed coat was penetrated later by the fruiting stalks of the fungus, which was found to be a new species of Podosporiella. The fungus is not considered to be a true parasite, since it does not attack the kernel until about the time of germination, and has never been found in the growing portions of the plant. The disease is found to be most prevalent in volunteer wheat, and where several crops have been grown with only surface cultivation.

The utilization of certain pentoses and compounds of pentoses by Glomerella cingulata. L. A. HAWKINS, *U. S. Department of Agriculture, Washington, D. C.*

In the experiments an attempt was made to determine the effect of the apple bitter rot fungus upon the pentose containing compounds of the apple fruit, the relative value of certain pentoses and compounds of pentoses as sources of carbon for this fungus and the effect of an aqueous extract of the fungus mycelium upon xylan. It was found that the fungus increased the alcohol soluble pentosan content of the apple fruit but decreased the total pentosan content. The fungus readily utilized either xylose, arabinose, xylan or arabin as sources of carbon. The two pentoses were more favorable sources of carbon than glucose. Aqueous extracts of the fungus mycelium when allowed to act on xylan produced xylose. It is evident that the fungus secretes an enzyme which hydrolyzes xylan to xylose.

Armillaria or oak fungus disease in California. W. T. HORNE, *University of California, Berkeley, Cal.*

Cultures and specimens were exhibited and the action of the fungus briefly described. There was considerable discussion of this important disease by a number of those present.

Wednesday, August 4, was spent with the botanists at Stanford University, and the plant pathologists joined the biologists in a dinner in San Francisco in the evening.

Following the reading of Doctor Shear's paper, upon motion, the chairman was directed to appoint a committee for the purpose of considering the question of the establishment of a culture supply laboratory. The committee appointed was C. L. Shear, chairman, and L. R. Jones, with power to select a third member.

In the intermission between the second and third sessions, a business meeting of the Pacific Division was held, in which a report was made by the secretary-treasurer as to the activities of the division and its financial condition. Officers for the ensuing year were elected as follows: H. S. Jackson, president; J. T. Barrett, vice-president; W. T. Horne, secretary-treasurer.

The matter of affiliation with the Pacific Division of the American Association for the Advancement of Science was reported on and the matter of the next meeting was left until the next meeting of that society should be decided. The question of relation to the parent society was then taken up and the report of a joint committee was adopted so that affiliation will be accomplished when the report has been adopted by the parent society. The adoption of this report changes the name of the local society to the American Phytopathological Society, Pacific Division, and also establishes the distinction originally made between associate and active members, active members being those who are also members of the parent society.

C. L. SHEAR
Secretary-Treasurer
WM. T. HORNE
Secretary-Treasurer,
Western Division

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